UCRL-ID-142542

LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

Printed Wiring Board Fabrication and Lead Elimination Via Single-Bath Electrodeposition

M. P. Meltzer, C. P. Steffani

February 21, 2001

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

Printed Wiring Board Fabrication and Lead Elimination via Single-Bath Electrodeposition

Principal Investigator: Michael P. Meltzer, Environmental Protection Department, ORAD/PRAG

Co-investigator: Christopher P. Steffani, Manufacturing & Materials Engineering Division

Tracking Code: 97-ERD-032

Printed wiring board (PWB) fabrication, an operation performed both at LLNL and throughout the electronics industry, generates considerable quantities of hazardous waste, notably lead-bearing materials used for soldering, tinning, and finish coating the circuits of the board. Hot-air solder leveling (HASL), the most common method of finishing is one of the main sources of hazardous lead-bearing wastes in traditional PWB manufacturing. The development of a safer finishing method will lead to employee health and environmental benefits. In addition, there is a production advantage to eliminating HASL, for it provides a fairly uneven surface that is problematic for mounting very small components.

In this project, we developed "single-bath electroplating" as a potential HASL replacement technology for many applications. Single-bath electroplating involves alternating deposition of one or the other metal component of a bimetal bath, through control of plating potential and mass transport. It employs a nickel layer as both etch resist and finish coat and has the potential for lowering environmental and human-health risks associated with PWB manufacture—while at the same time reconfiguring the process for greater efficiency and profitability.

During FY2000, for the PWB application developed in this project, we adapted techniques from layered electroforming methods that are used to build up copper-nickel composite materials of high tensile strength. These materials typically have many alternating, extremely thin layers of each metal. We altered the electroforming process parameters so that we could deposit the thicker layers of copper required for PWB circuitry.

The single-bath process generates copper deposits from a very dilute solution of copper ions (0.05-0.1 M), versus 2.0 M for traditional PWB applications. In our single-bath approach, nickel concentrations are an order of magnitude greater than those of copper, and special complexing agents are used to modify reduction potentials. Solution pH is also controlled very closely. Amperometric manipulation is performed concurrently with agitation variations to insure the deposition of distinct layers of copper and nickel. Copper thicknesses on the order of 12 microns (0.0005") and nickel thicknesses of 1 micron (0.00004") are achieved by this approach.

Single-bath electroplating is applied to PWB fabrication as follows. Copper is plated first, to the desired thickness of the PWB's circuitry — typically 12 microns (0.0005"). Next, a nickel layer is deposited as an etch resist to protect copper circuitry. The etch-resist layer is left in place rather than stripped (as tin and tin/lead etch resists generally are) and serves as a finish coat for the PWB, onto which components are soldered. Our analyses demonstrated that this nickel layer, which contains a significant percentage of copper because of the chemistry of the process, provides a good solderable surface.

Our process (1) meets PWB-manufacturing requirements for level, bright, durable deposits and for a solderable nickel layer; (2) eliminates a costly, labor-intensive operation that also generates significant hazardous waste, because our nickel etch-resist layer does not have to stripped and discarded; (3) eliminates use of highly toxic lead-bearing materials from several PWB manufacturing steps, including etch-resist deposition, finish coating, and tinning; and (4) combines several fabrication steps into one tank, by depositing either copper (for circuitry) or nickel (for an etch-resistant finish) from the same bath. This can reduce equipment requirements as well as the floor space "footprint" needed for manufacturing PWBs. In many shops, footprint reductions can have a significant impact on reducing production costs.

A patent on single-bath electroplating has been applied for (LLNL Patent Office File Number IL10598), and an industry sponsor, Shipley Company (a division of Rohm and Haas) is funding continued development of the technology.